Report for 2005NJ82B: Examining Effects of Soil Compaction on Pollutant Removal Efficiency and Lifespan of a NJ Approved Stormwater Best Management Practice

Publications

- There are no reported publications resulting from this project.

Report Follows

The Problem

Probably the greatest detrimental change to water quality is due to urbanization. Urbanization is the change of land use from natural or agricultural, and it occurs in several steps. Urbanization changes the atmospheric composition, the hydrology of the watershed, the receiving streams and other water bodies, and the soil. Waste emissions increase dramatically. The sources of these emissions are industries, transportation, household heating, sewage conveyance and disposal, garbage collection and disposal, litter deposition, fallen leaves on impervious surfaces, and street salting just to name a few (Young *et al.* 1996).

Findings from the Nationwide Urban Runoff Program (NURP) instituted by the United States Environmental Protection Agency (USEPA) confirmed that the most ubiquitous constituents discovered in urban stormwater runoff are metals (USEPA 1983). According to Marsalek *et al.*, 1999, the constituents which predominately produce adverse effects on surrounding bodies of water are lead, copper, and zinc. The source of these metals is ubiquitous, and due to the inability of the surrounding environment to destroy or transform these constituents, urban stormwater runoff is of great concern to our watersheds (FHWA 1998).

Total Maximum Daily Loads (TMDLs) for metals are created in an effort to identify sources of point and non-point pollution in impaired bodies of water. Currently, there are 11,230 waterways impaired by metals within the United States (USEPA 2005). Two hundred eighty one of these impairments are located in the State of New Jersey. It is of importance to note that impairment by metals account for approximately 20% of the state's impairments (NJDEP 2005). It is of greater importance to note that the impairment by metals account for approximately 19% of the total impairments in the nation's waterways. Metals account for the highest number of impairments in the nation (USEPA 2005). For this reason, it is of principal importance to provide treatment alternatives for the mitigation of these impairments. Currently the most accepted form of treatment for polluted stormwater is the development of structural stormwater best management practices (BMPs).

Due to the increasing awareness of the potential hazards of metals in the nation's waterways, legislation and control measures under the National Stormwater Program are in effect or are pending (USEPA 1999). Control measures include the Surface Water Quality Standards created by the New Jersey Department of Environmental Protection (NJDEP) for the regulation of safe levels of water quality throughout the local waterways. Surface water quality criteria for lead, copper, and zinc are designated as 5 µg/L, 5.6 µg/L, and 120 µg/L respectively. These numbers represent the chronic criteria as a four-day average, expressed in maximum concentrations of micrograms per liter (NJDEP 2005).

In addition, soil loss from construction sites can reach magnitudes of over 100 tons per hectare per year. A few percent of the watershed under construction can contribute a major portion of the sediment being carried by the stream, thus affecting the streams themselves, sometimes irreversibly. Straightening and lining with concrete destroys the natural habitat, and the streams can no longer support fish and other biotic populations. Also, increased imperviousness increases the volume of surface runoff, while at the same time diminishes groundwater recharge.

Furthermore, unsewered communities are typically served by on-site disposal systems such as septic tanks that discharge the wastewater into the soil. Septic tanks provide only minimal treatment by sedimentation and anaerobic decomposition. There are approximately fifty million households in the United States with septic systems, representing the highest total volume of wastewater discharged to the groundwater and the most recorded source of groundwater contamination. When the adsorption capacity of the soil is exhausted, contamination of surface waters by organics and pathogenic microorganisms may occur and be severe (Pitt *et al*. 1996).

In addition, the use of lawn care chemicals in the American suburbs is also a concern. The typical suburban dweller with a lawn uses more chemicals, i.e. fertilizers and pesticides, per lawn area than a farmer would. Therefore, losses of these chemicals into surface and groundwater can be considerable. A steady increase of nitrate contamination of groundwater as well as detection of the chemicals in suburban surface runoff is often exhibited (Novotny 1995).

One of the key water quality stormwater management techniques is bioretention (sometimes referred to as "rain gardens"). Bioretention is a terrestrial-based, water quality, and water quantity control practice using the chemical, biological, and physical properties of plants, microbes, and soils for removal of pollutants from stormwater runoff. Some of the processes that may take place in a bioretention facility include sedimentation, adsorption, filtration, volatilization, ion exchange, decomposition, phytoremediation, bioremediation, and storage capacity.

Bioretention is a fairly new best management practice (BMP), developed in 1987 by Prince George's County, Maryland (PGDER 1993), to be employed by the United States Environmental Protection Agency (USEPA 1999) and the New Jersey Department of Environmental Protection (NJDEP 2000). It can be conceptualized as a modified infiltration trench (Young et al. 1996; USEPA 1999). Bioretention areas are originally modeled after the hydrologic and physical characteristics of an upland terrestrial forest or a meadow, as opposed to a wetland community (Coffman and Winogradoff). Typically designed with indigenous trees, shrubs, and grasses known to have high pollutant removal capacities, the bioretention cell can provide both stormwater quantity and quality control (NJDEP 2004). Bioretention areas typically consist of a surrounding grass buffer strip, sand bed infiltration area, ponding area, organic mulch layer, planting soil, and plants. The typical bioretention area consists of five basic features: pretreatment, treatment, conveyance, maintenance reduction, and landscaping (Environmental Protection Handbook).

A well-designed bioretention area consists of: (1) a grass filter strip (or grass channel) between the contributing drainage area and the ponding area, (2) ponding area containing vegetation with a planting soil bed, (3) organic/mulch layer, (4) gravel and perforated pipe underdrain system to collect runoff that has filtered through the soil layers (bioretention areas can optionally be designed to infiltrate into the soil).

Bioretention area design will also include some of the following: (1) optional sand filter layer to spread flow, filter runoff, and aid in aeration and drainage of the planting soil, (2) a stone diaphragm at the beginning of the grass filter strip to reduce runoff velocities and spread flow into the grass filter, and (3) an inflow diversion or an overflow structure consisting of one of five main methods: (a) a flow diversion structure, (b) an inlet deflector, (c) a slotted curb with the parking lot graded to divert the runoff into the facility, (d) a short deflector weir (maximum height 6 inches) designed to divert the maximum water quality peak flow into the bioretention area, and (e) an in-system overflow consisting of an overflow catch basin inlet and/or a pea gravel curtain drain overflow (PGDER 1993).

During construction of the basin, the planting soil bed may be subject to compaction by construction equipment (Pitt *et al*. 2002). The use of equipment with narrow tracks or narrow tires, rubber tires with large lugs, or high pressure tires will cause excessive compaction resulting in reduced infiltration rates and is unacceptable. Compaction will significantly contribute to design failure (PGDER 1993). Metals are of particular concern because of possible buildup within treatment facilities which raises questions about their long-term fate (Davis *et al*. 2003). Also, metals such as lead, copper, and zinc present a health risk when exceeding the regulated criterion (Pitt *et al*. 1996).

The design of a bioretention system must account for soil compaction within the basin. Compaction can be defined as a process of densification due to the removal of air voids when external stress is applied to the soil (Gray 2002). The effects of soil compaction on soil strength, hydraulic conductivity, and volume stability have been investigated thoroughly (Lambe and Whitman 1969; Seed and Chan 1959). Compaction in soil influences plant growth in multiple dimensions, primarily based on the degree of compaction. High levels of soil compaction result in high soil bulk densities to a degree at which plant roots are hindered from penetrating the soil. Furthermore, due to the high bulk density of compacted soils, filtration rates though the soil media are reduced, causing excessive runoff though the system, and therefore affecting the efficiency of bioretention BMPs. The bioretention media is provided inadequate time to adsorb the metals and the efficiency of the BMP is reduced (Pitt *et al*. 2002).

A bioretention area is an innovative practice for pollutant control. It is a facility that combines the concepts of detention ponds and bioretention in an attempt to provide higher overall pollutant removal. However, little is known about the overall efficiency of bioretention. Typical bioretention facilities consist of a vegetated strip of land that allows stormwater percolation for biological and physical treatment. Bioretention is typically used in an area of 1 acre or less and consists of an excavated bed filled with sand and covered with a layer of permeable soil. Terrestrial vegetation with a high moisture tolerance is suggested for planting in bioretention areas.

Bioretention areas are presumed to be able to remove 80% of the total suspended solids (TSS) load in typical urban post-development runoff when sized, designed, constructed, and maintained in accordance with the recommended specifications. Undersized or poorly designed bioretention areas can reduce TSS removal performance. The following design pollutant removal rates are conservative average pollutant reduction percentages for design purposes derived from sampling data, modeling, and professional judgment. In a situation where a removal rate is not deemed sufficient, additional controls may be put in place at the given site in a series or "treatment train" approach (Davis *et al*. 2003).

- Total Suspended Solids – 80%
- Total Phosphorus – 60%
- Total Nitrogen – 50%
- Fecal Coliform – insufficient data
- Heavy Metals – 80%

But what happens when the bioretention area is being built, and the planting soil gets compacted? Our investigation will explore five degrees of soil compaction within the bioretention basin. Soil compaction levels will range from light bulk densities (1.07 g/cm^3) to growth-limiting bulk densities (1.65 g/cm^3). This will be accomplished though five sets of bench scale bioretention column systems. The metal removal efficiency of the bioretention system for each degree of compaction will be analyzed. Also, an analysis of the metal removal efficiencies will provide a discussion for the optimal degree of soil compaction necessary for the optimization of the bioretention system. This investigation will assist in the mitigation of our nation's impaired waterways and provide support for further research in this field.

Methodology

For this experiment, fifteen columns were constructed using 8-inch in diameter schedule 40 PVC (poly vinyl chloride) piping (AASHTO M-278). Three of these columns were see through, or clear; the rest were the standard white. Each of these columns had an 8-inch to 6-inch reducing coupling and a 6-inch end cap on one end with the other end open to the atmosphere of the laboratory. Into the end cap of each column, a quarter inch whole was drilled, using a brand new titanium drill bit, to allow the synthetic runoff water to flow through. The end that was open to the atmosphere was covered by placing an autoclave bag over the entire pipe. Between the pipe and the reducer coupling was a single layer of filter fabric, while the reducer coupling below was filled with pea gravel (AASHTO M-43).

All of the columns in this experiment were designed to hold 18 inches of soil, rather than the minimum of 3 feet required by the New Jersey Department of Environmental Protection (NJDEP), and 2 inches of mulch with 6-8 inches to spare, for the ponding of the synthetic runoff water. The soil used was consistent with that of the planting soil of a bioretention area: one-third compost, one-third topsoil, and one-third sand (AASSHTO M-6/ASTM C-33). For this experiment, the one foot sand filter at the bottom of the planting soil was not used These columns were separated into five groups of three, with each group of three holding a different amount of the bioretention area planting soil mix. The first group, which was called Series A, held 35 pounds of soil mix; Series B held 40 lbs. of soil mix; Series C held 45 lbs., Series D held 50 lbs., and Series E held 55 pounds of soil mix. The soil was

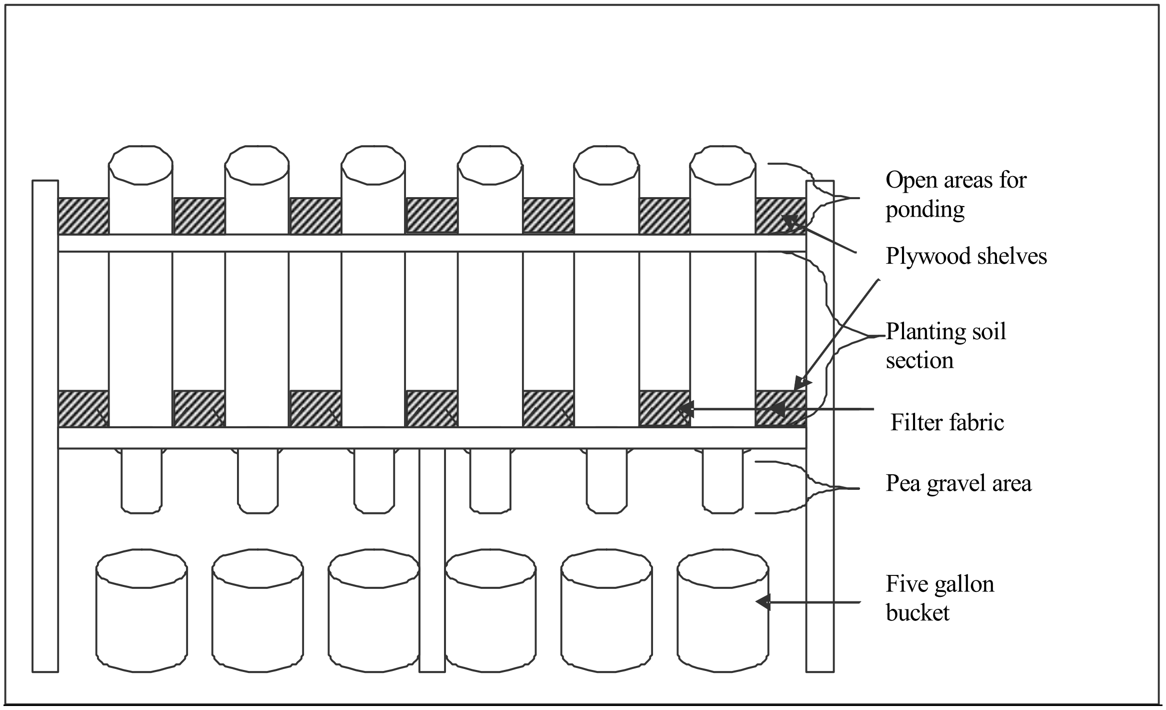

Figure 1: Schematic of bench containing six experimental bioretention area columns.

compacted using a circular piece of plywood, a two-foot section of a 2″ by 4″, and a small sledgehammer.

Three benches were constructed using heavy-duty plywood, 2″ by 4″s, metal brackets, and screws. Each bench was designed to hold six columns, and to hold each column high enough in order to slide a five-gallon pail under the column to facilitate the collection of: whatever synthetic runoff water flowed through the column, and the samples. The last bench held only three columns, even though it was designed to hold six. These benches were approximately 8 feet long, 2 feet wide, and four feet high. They had two shelves with wholes cut in them, for the columns. The 8-inch by 6-inch reducer coupling rested on the lower shelf with the six-inch side of the reducer coupling able to protrude, but not the eight-inch side, see Figure 1 below.

According to the NJDEP's New Jersey Stormwater Best Management Practices Manual (2004) a stormwater quality design storm has a total depth of 1.25 inches and a total duration of 2 hours, or 0.625 in/hr (0.265 mm/min) for 2 hours. This is based on rainfall data collected between 1913 and 1975 in Trenton, New Jersey.

Furthermore, according to the Bioretention Manual (2002), developed by Prince George's County, Maryland, the minimum size for a bioretention area is 7.2% of the drainage area. For this experiment, each experimental bioretention area column was set at 5% of the total drainage area. Then, each column was potentially draining an area approximately 1005.3 square inches (about 7 square feet). Going further, using a stormwater quality design storm and the rational method with a coefficient of 0.8, each bioretention area column would be filtering approximately 8.37 cubic inches per minute (137.21 mL/min).

Business	
Downtown Areas	0.70 – 0.95
Neighborhood Areas	0.50 – 0.70
Residential	
Single-family	0.30 – 0.50
Multi-family detached	0.40 – 0.60
Multi-family attached	0.60 – 0.75
Residential suburban	0.25 – 0.40
Apartments	0.50 – 0.70
Parks, cemeteries	0.10 – 0.25
Playgrounds	0.20 – 0.35
Railroad yards	0.20 – 0.40
Unimproved areas	0.10 – 0.30
Drives and walks	0.75 – 0.85
Roofs	0.75 – 0.95
Streets	
Asphalt	0.70 – 0.95
Concrete	0.80 – 0.95
Brick	0.70 – 0.85

Table 1: General runoff coefficients for the rational method, adapted from Thompson 2005.

The rational method, first developed in 1889 by Kuichling, is a simple technique for estimating a design discharge from a small watershed. In fact, it was developed for small drainage basins in urban areas. The rational method (Q = CIA) is the basis for the design of many small structures. The A in the equation stands for the area of the drainage basin. The I stands for the average rainfall intensity, and the C stands for the runoff coefficient, representing a ratio of runoff to rainfall. The runoff coefficient is the variable of the rational method least susceptible to precise determination and requires judgment and understanding on the part of the designer. Table 1 lists the recommended ranges for the runoff coefficient value classified with respect to the general land use.

The 137.21 mL/min per each of the 15 column turns out to be a total of 246,978 mL or 65.25 gallons for the two hour design storm. To transport all of this synthetic runoff water, two 20-gallon white plastic drums and two 50-liter carboys were used. To deliver the 137.21 mL/min to each column required the use of pumps (Masterflex model # EW-07553-70 L/S variable speed) and pump heads (Masterflex model # EW-07016-20 standard pump head for L/S 16 tubing) and of course tubing (Masterflex 06404-16 norprene). To cut down on costs, only three pumps and nine pump heads were purchased for this experiment. Each pump held three pump heads, so only three sets of three columns could be run at a time, rather than running all fifteen columns at the same time.

The synthetic runoff water was modeled after Davis *et al*. (2001) which was based on runoff sampling data obtained by Prince George's County (PGDER 1993). Table 2 specifies the recipe for the synthetic runoff water. However, since this experiment used two of each of the two different sized containers, two different mixtures of chemicals were required. Furthermore, since four containers were used in this experiment, each of the two different mixtures had to be prepared twice. This was done in the concentrated form in a 500-mL container. The two 20-gallon and the two 50-liter containers were filled with qualitative water (Q-water) with a resistance of 17.5 – 17.7 megohm-cm or better. This had to be done for each of the eight different runs of this experiment.

The samples were first collected in 500-mL Nalgene polypropylene containers (02-893C Fisher Scientific, www.fishersci.com). Then a Target all-plastic 20-mL syringe (03-377-24 Fisher Scientific, www.fishersci.com) was used to remove the

Pollutant	Chemical	Concentration (mg/L)
Nutrients		
Nitrate	$NaNO_3$	2 (as N)
Phosphate	Na_2HPO_4	0.6 (as P)
Heavy Metals		
Copper	$CuSO_4$	0.08 (as Cu)
Lead	$PbCl_2$	0.08 (as Pb)
Zinc	$ZnCl_2$	0.6 (as Zn)
Dissolved Solids	$CaCl_2$	120
pH		7.0

Table 2: Synthetic stormwater recipe modeled after the recipe used by Davis *et al.* 2001 which was based on data obtained by Prince George's County.

sample from the 500-mL container. The next step in acquiring the sample, was to attach an Acrodisc ion chromatography syringe filter (28143-292 VWR International, www.vwr.com) to the syringe and push 10-mL of the sample through the filter into a Corning Brand 15-mL centrifuge tube (05-538-53F Fisher Scientific, www. fishersci.com). Anything that was to come into contact with the sample was first washed with 10% hydrochloric acid (HCl). This was done by filling the items with 10% HCl and then letting them sit in an oven (Fisher Scientific 13-247-637G, www.fishersci.com) at 60 degrees C overnight. Upon taking the items out in the morning to cool, they were inverted. Once they had cooled, each item was rinsed 5 times with Q-water.

Prior to starting the first run, two gallons of steam distilled water was poured into each column. This was done mainly to wet down the planting soil mix, but it was also used to see whether or not the column would change the pH of the synthetic runoff water. For this run, thirty gallons of distilled water were purchased from local grocery stores, and two gallons were poured slowly into each bioretention area column. The pH was taken prior to the pouring, using a calibrated Accumet Basic pH meter (Fisher Scientific, 13-636-AB15P, www.fishersci.com), by adding a pinch (0.1 g) of salt (NaCl) to 200 mL of the distilled water. The pH was taken after the distilled water had flowed through the column by collecting a sample in a Corning Brand 15-mL centrifuge tube from each column and measuring the pH of each sample.

The second run was conducted two weeks after the columns were wet down and was the first of the eight runs using Q-water. This run was used to collect enough of the samples in order to develop the methods for analysis, i.e. after collecting the sample in the 500-mL container three 10-mL samples were collected instead of one, one for each metal. This was done for each sampling time, or a total of three times. Each sample was then preserved using Optima nitric acid (Fisher Scientific, A467-250, www.fishersci.com). Enough nitric acid was added to lower the pH of the sample to 2 or below, which made each sample about a 0.2% solution of nitric acid.

For the 2nd through the 8th runs, only one 10-mL sample was collected per column per sampling time. Since the design storm was a 2-hour event, a sample was collected when the synthetic runoff water first started coming out of the column, another sample was collected 1-hour later, and the final sample was collected from the last of the synthetic runoff water to flow through the columns. Except for the last run during which only the first and last samples were collected, due to the fact that the Corning Brand 15-mL centrifuge tubes were running low.

In addition to analyzing for lead, copper, and zinc; nitrate and phosphate were also analyzed. One 125-mL Nalgene polypropylene container (Fisher Scientific, www.fishersci.com) was filled from the stormwater runoff flowing through each column for each run for this purpose. One 125-mL sample of the synthetic stormwater runoff from each of the four containers (two 20-gallon and two 50-liter) was collected as well. Lead, copper, and zinc were analyzed by graphite furnace atomic absorption spectrophotometry (Perkin Elmer, 4100ZL, www.las.perkinelmer.com). Lead was analyzed using USEPA's method #239.2 with a concentration range of 5-100 μg/L and a detection limit of 1 μg/L. Copper was analyzed using USEPA's method #220.2. The concentration range was 5-100 μg/L, and the detection limit was 1 μg/L. Zinc was analyzed using USEPA's method #289.2 with a concentration range of 0.2-4 μg/L. The method detection limit was 0.05 μg/L. No matrix modifiers were used in any of these methods; however, all three methods required optimization. Only the Zinc method required the dilution of the sample, and in order to calibrate, the background correction had to be turned off for this method as well. Nitrate and phosphate were analyzed by flow injection analysis spectrophotometry (Lachat, QuikChem 8500, www.lachatinstruments.com). Nitrate was analyzed using Lachat's method #10-107-04-1-A. The concentration range was 0.2-20 mg NO_3-N/L, and the detection limit was 0.01 mg NO_3-N/L. Phosphate was analyzed using Lachat's method #10-115-01-1-A with a concentration range of 0.01-2 mg PO_4-P/L, and a detection limit of 0.002 mg PO_4-P/L.

Principal Findings and Significance

The lead, copper, and zinc data are included in Tables 3 through 17 which follow, and the nitrate and phosphate data can be found in Tables 18 to 32.

Column 1

Date	Run	Pb in			Pb out			Cu in			Cu out			Zn in			Zn out		
					ND	±					16.5	±	2.54				6.45	±	1.812
20-Oct	first run	36.1	±	1.33	ND	±		69.7	±	3.05	21.1	±	1.56	533.5	±	0.906	3.92	±	0.231
					ND	±					18.6	±	2.12				2.34	±	0.442
								MDL		0.57				MDL		0.66			
					ND	±					13.2	±	1.29				22.26	±	0.873
3-Nov	second run	8.1	±	0.74	ND	±		10.2	±	0.76	10.1	±	1.25	217.1	±	0.708	11.12	±	0.65
					ND	±					10.2	±	0.78				4.02	±	0.313
								MDL		0.44				MDL		0.26			
					ND	±					18.9	±	2.99				11.54	±	0.347
17-Nov	third run	24.6	±	0.96	ND	±		85.8	±	13.07	9.7	±	0.56	508.2	±	0.398	7.88	±	0.782
					ND	±					9	±	1.26				8.17	±	1.166
								MDL		0.46				MDL		0.76			
					1.8	±	0.09				10.8	±	0.9				21.5	±	2.9
1-Dec	fourth run	18.2	±	0.36	1.9	±	0.23	64.8	±	1.59	10.5	±	0.38	524	±	2.55	16.9	±	1.1
					2	±	0.61				11.1	±	0.29				3.8	±	0.43
		MDL		0.1				MDL		0.33				MDL		0.55			
					0.5	±	0.07				9.7	±	2.31				17.6	±	0.04
15-Dec	fifth run	36.6	±	1.94	1.2	±	0.05	68.9	±	0.48	11.2	±	0.82	120	±	0.01	12	±	0.39
					1.2	±	0.14				8.6	±	0.21				2.9	±	0.23
		MDL		0.1				MDL		0.31				MDL		0.48			
					ND	±					9.8	±	2.09				8.6	±	0.46
22-Dec	sixth run	29.2	±	0.1	0.4	±	0.25	60.6	±	1.37	9.7	±	0.22	226	±	3.35	9.8	±	1.18
					5.2	±	0.58				9.5	±	0.3				5.4	±	0.67
		MDL		0.38				MDL		0.29				MDL		0..57			
					ND	±					12	±	2.22				61.8	±	1.21
29-Dec	seventh run	9.4	±	0.08	0.3	±	0.19	65	±	3.6	8.6	±	0.16	338	±	0.56	59.9	±	0.52
					0.5	±	0.34				7.6	±	0.25				18.8	±	0.52
		MDL		0.09				MDL		0.32				MDL		0.63			
13-Feb	eighth run	0			ND	±		0			8.4	±	1.97	0			22.1	±	1.29
					0.4	±	0.14				6	±	0.13				10.2	±	0.64
		MDL		0.09				MDL		0.27				MDL		0.43			

Table 3: Metals data for bioretention area column 1

Column 2

Date	Run	Pb in			Pb out			Cu in			Cu out			Zn in			Zn out		
20-Oct	first run	36.1	±	1.33	ND	±		69.7	±	3.05	14.1	±	1.84	533.5	±	0.906	12.69	±	3.946
					ND	±					21.9	±	2.37				4.35	±	0.111
					ND	±					17.4	±	1.91				1.6	±	0.085
3-Nov	second run	8.1	±	0.74	ND	±		10.2	±	0.76	15.7	±	0.82	217.1	±	0.708	29.8	±	0.752
					ND	±					12.7	±	0.42				8.03	±	0.154
					ND	±					12.3	±	0.21				5.53	±	0.086
17-Nov	third run	24.6	±	0.96	ND	±		85.8	±	13.07	19.6	±	1.49	508.2	±	0.398	13.18	±	0.203
					ND	±					15.3	±	0.58				9.81	±	0.082
					ND	±					13.7	±	0.92				11.29	±	0.233
1-Dec	fourth run	18.2	±	0.36	5.3	±	0.2	64.8	±	1.59	15.2	±	0.44	524	±	2.55	177	±	6.9
					2	±	0.04				13.9	±	0.45				20.4	±	2.4
					2.3	±	0.81				12.9	±	0.03				5.4	±	0.2
15-Dec	fifth run	36.6	±	1.94	0.5	±	0.16	68.9	±	0.48	11.4	±	0.61	120	±	0.01	25.6	±	0.18
					0.9	±	0.16				10.3	±	0.03				8.4	±	0.26
					0.8	±	0.06				10.3	±	0.12				6.3	±	0.72
22-Dec	sixth run	29.2	±	0.57	0.2	±	0.18	60.6	±	1.37	11.1	±	1.13	226	±	3.35	43.6	±	1.18
					ND	±					11.4	±	0.33				22.4	±	0.49
					1.4	±	0.44				9.4	±	0.38				10.7	±	0.56
29-Dec	seventh run	9.4	±	0.69	ND	±		65	±	3.6	13.2	±	0.51	338	±	0.56	76.3	±	0.35
					ND	±					11.2	±	0.4				66.1	±	0.91
					ND	±					13.4	±	0.19				32	±	0.44
13-Feb	eighth run		0		1.3	±	1.02		0		10	±	0.85		0		46.9	±	0.77
					0.2	±	0.46				8.1	±	1.98				14.1	±	0.42

Table 4: Metals data for bioretention area column 2

Column 3

Date	Run	Pb in	Pb out	Cu in	Cu out	Zn in	Zn out
20-Oct	first run		ND ±		25.2 ± 0.1		3.64 ± 1.244
		36.1 ± 1.33	ND ±	69.7 ± 3.05	28.1 ± 0.59	533.5 ± 0.906	8.61 ± 2.832
			ND ±		25 ± 1.8		4.31 ± 0.028
3-Nov	second run		ND ±		13.4 ± 0.38		27 ± 0.868
		8.1 ± 0.74	ND ±	10.2 ± 0.76	12.2 ± 0.15	217.1 ± 0.708	13.81 ± 0.443
			ND ±		8.8 ± 1.01		1.73 ± 0.071
17-Nov	third run		ND ±		15.3 ± 1.13		11.53 ± 0.293
		24.6 ± 0.96	ND ±	85.8 ± 13.07	12.9 ± 0.3	508.2 ± 0.398	7.69 ± 0.191
			ND ±		11.6 ± 0.75		6 ± 0.131
1-Dec	fourth run		2.1 ± 0.04		11.3 ± 1.03		59.6 ± 0.43
		18.2 ± 0.36	2.2 ± 0.49	64.8 ± 1.59	10.8 ± 0.1	524 ± 2.55	18.7 ± 0.36
			1.8 ± 0.13		9.3 ± 0.2		2.5 ± 0.42
15-Dec	fifth run		0.2 ± 0.23		8.6 ± 0.59		19.2 ± 0.24
		36.6 ± 1.94	0.5 ± 0.14	68.9 ± 0.48	7.2 ± 0.06	120 ± 0.01	10.2 ± 0.03
			0.8 ± 0.01		6.9 ± 0.16		3.6 ± 0.17
22-Dec	sixth run		0.2 ± 0.16		8.2 ± 0.89		44.1 ± 9.11
		29.2 ± 0.57	0.1 ± 0.14	60.6 ± 1.37	8.4 ± 0.75	226 ± 3.35	4.2 ± 0.68
			0.8 ± 0.46		11.1 ± 0.31		1.3 ± 0.37
29-Dec	seventh run		ND ±		9.8 ± 0.68		81.8 ± 1.47
		9.4 ± 0.69	ND ±	65 ± 3.6	7.7 ± 0.16	338 ± 0.56	39.4 ± 0.49
			0.4 ± 0.13		7.2 ± 0.1		18.5 ± 0.63
13-Feb	eighth run	0	0.5 ± 0.25	0	6.7 ± 0.87	0	25.9 ± 1.09
			ND ±		6.6 ± 1.27		14.9 ± 0.41

Table 5: Metals data for bioretention area column 3

Column 4

Date	Run	Pb in	Pb out	Cu in	Cu out	Zn in	Zn out
20-Oct	first run	36.1 ± 1.33	ND ±	69.7 ± 3.05	21.1 ± 0.71	533.5 ± 0.906	6.28 ± 0.547
			ND ±		18.5 ± 1.33		4.34 ± 0.157
			ND ±		14.9 ± 2.43		3.22 ± 0.14
3-Nov	second run	8.1 ± 0.74	ND ±	10.2 ± 0.76	11.6 ± 0.2	217.1 ± 0.708	23.73 ± 0.265
			ND ±		14.1 ± 0.2		9.56 ± 0.183
			ND ±		12.4 ± 0.61		3.49 ± 0.13
17-Nov	third run	24.6 ± 0.96	ND ±	85.8 ± 13.07	11.7 ± 0.04	508.2 ± 0.398	16.42 ± 0.271
			ND ±		14.7 ± 0.43		9.06 ± 0.029
			0.5 ± 0.49		12.9 ± 0.23		7.3 ± 0.155
1-Dec	fourth run	18.2 ± 0.36	2.7 ± 0.13	64.8 ± 1.59	9.4 ± 0.56	524 ± 2.55	28.5 ± 1.66
			2.1 ± 0.1		9.6 ± 0.22		21.3 ± 1.13
			2.2 ± 0.14		9.3 ± 0.26		7.8 ± 0.81
15-Dec	fifth run	36.6 ± 1.94	0.2 ± 0.14	68.9 ± 0.48	9.5 ± 0.84	120 ± 0.01	25.1 ± 0.24
			0.3 ± 0.09		8.1 ± 0.19		10.8 ± 0.29
			0.5 ± 0.18		7.1 ± 0.11		5 ± 0.65
22-Dec	sixth run	29.2 ± 0.57	ND ±	60.6 ± 1.37	11.3 ± 0.88	226 ± 3.35	26 ± 2.32
			ND ±		10.8 ± 0.33		6.2 ± 2.15
			0.1 ± 0.67		8.6 ± 1.17		0.9 ± 0.5
29-Dec	seventh run	9.4 ± 0.69	ND ±	65 ± 3.6	7.9 ± 0.7	338 ± 0.56	57 ± 0.5
			ND ±		7.4 ± 0.52		32.2 ± 0.05
			0.2 ± 0.13		5.2 ± 1.24		15 ± 0.63
13-Feb	eighth run	0	0.4 ± 0.45	0	15.4 ± 0.4	0	17.1 ± 0.51
			ND ±		5.1 ± 0.41		10.7 ± 0.17

Table 6: Metals data for bioretention area column 4

Column 5

Date	Run	Pb in	Pb out	Cu in	Cu out	Zn in	Zn out
		in	out	in	out	in	out
20-Oct	first run		ND ±		20.7 ± 1.41		3.08 ± 0.261
		36.1 ± 1.33	ND ±	69.7 ± 3.05	14.1 ± 1.05	533.5 ± 0.906	8.49 ± 0.121
			ND ±		13.5 ± 2.61		3.18 ± 0.257
3-Nov	second run		ND ±		10.6 ± 0.1		23.04 ± 1.369
		8.1 ± 0.74	ND ±	10.2 ± 0.76	10.4 ± 0.28	217.1 ± 0.708	5.33 ± 0.276
			ND ±		11.1 ± 0.35		21.39 ± 0.67
17-Nov	third run		ND ±		10.6 ± 0.95		13.22 ± 0.076
		24.6 ± 0.96	ND ±	85.8 ± 13.07	15.6 ± 0.49	508.2 ± 0.398	9.3 ± 0.212
			1.1 ± 0.53		15.5 ± 0.47		6.38 ± 0.212
1-Dec	fourth run		2.2 ± 0.69		8.7 ± 0.48		42 ± 0.36
		18.2 ± 0.36	2.2 ± 0.87	64.8 ± 1.59	8.6 ± 0.22	524 ± 2.55	22.4 ± 1.69
			2.4 ± 0.95		7.4 ± 0.2		9.3 ± 0.65
15-Dec	fifth run		0.3 ± 0.09		10.8 ± 0.75		11.5 ± 0.29
		36.6 ± 1.94	0.2 ± 0.08	68.9 ± 0.48	6.5 ± 0.25	120 ± 0.01	11.8 ± 0.04
			0.3 ± 0.15		6 ± 0.63		4.5 ± 0.51
22-Dec	sixth run		ND ±		12.3 ± 0.25		20.8 ± 1.61
		29.2 ± 0.57	ND ±	60.6 ± 1.37	13.6 ± 0.19	226 ± 3.35	9.8 ± 2.44
			ND ±		11.3 ± 0.16		2.4 ± 0.68
29-Dec	seventh run		ND ±		9.8 ± 0.41		60.5 ± 0.55
		9.4 ± 0.69	ND ±	65 ± 3.6	8.3 ± 0.4	338 ± 0.56	64.6 ± 0.77
			0.4 ± 0.12		7.2 ± 0.38		18.4 ± 0.53
13-Feb	eighth run	0	ND ±	0	6 ± 0.59	0	30.8 ± 1.21
			ND ±		5.5 ± 1.48		11.2 ± 0.43

Table 7: Metals data for bioretention area column 5

Column 6

Date	Run	Pb in			Pb out			Cu in			Cu out			Zn in			Zn out		
20-Oct	first run	36.1	±	1.33	ND	±		69.7	±	3.05	23.4	±	1.56	533.5	±	0.906	3.33	±	0.582
					ND	±					17.7	±	1.37				3.76	±	0.121
					ND	±					20.7	±	4.2				1.24	±	0.043
3-Nov	second run	8.1	±	0.74	ND	±		10.2	±	0.76	9.4	±	0.99	217.1	±	0.708	21.73	±	0.712
					ND	±					12.3	±	0.15				7.33	±	0.246
					ND	±					10.6	±	0.29				6.07	±	0.058
17-Nov	third run	24.6	±	0.96	ND	±		85.8	±	13.07	9.8	±	0.33	508.2	±	0.398	16.3	±	0.205
					ND	±					13.9	±	0.53				10.4	±	0.046
					0.7	±	0.59				15.3	±	0.44				10.71	±	0.042
1-Dec	fourth run	18.2	±	0.36	2.1	±	0.07	64.8	±	1.59	8.9	±	0.27	524	±	2.55	33.8	±	0.52
					2.9	±	0.49				9.9	±	0.15				21.8	±	2.55
					4.6	±	1.17				10.4	±	0.41				4.4	±	1.03
15-Dec	fifth run	36.6	±	1.94	0.6	±	0.09	68.9	±	0.48	8.5	±	0.31	120	±	0.01	39	±	0.31
					0.7	±	0.07				6	±	0.3				12.6	±	0.51
					0.5	±	0.1				6.3	±	0.63				6.1	±	0.08
22-Dec	sixth run	29.2	±	0.57	ND	±		60.6	±	1.37	12.3	±	0.83	226	±	3.35	18.5	±	1.87
					ND	±					11.6	±	0.24				8.1	±	3.26
					ND	±					10.9	±	0.52				5.2	±	1.45
29-Dec	seventh run	9.4	±	0.69	ND	±		65	±	3.6	7.3	±	0.32	338	±	0.56	54.1	±	0.96
					0.4	±	0.05				6.7	±	0.03				39.7	±	0.61
					0.5	±	0.05				6.2	±	0.32				21.8	±	1.04
13-Feb	eighth run		0		ND	±			0		5.2	±	0.75		0		33.3	±	0.36
					ND	±					5.6	±	0.24				10.1	±	0.19

Table 8: Metals data for bioretention area column 6

Column 7

Date	Run	Pb in	Pb out	Cu in	Cu out	Zn in	Zn out
20-Oct	first run		ND ±		21.5 ± 1.35		4.58 ± 0.424
		41.9 ± 3.14	ND ±	29.6 ± 0.92	21.5 ± 1.54	565.7 ± 2.324	4.33 ± 0.226
			ND ±		21.5 ± 1.62		2.26 ± 0.07
3-Nov	second run		ND ±		8.8 ± 0.24		11.58 ± 0.44
		10.6 ± 0.83	ND ±	11.1 ± 0.07	11.7 ± 0.16	147.5 ± 0.105	7.64 ± 0.542
			ND ±		13.6 ± 0.78		5.43 ± 0.064
17-Nov	third run		ND ±		7.7 ± 0.51		14.94 ± 0.331
		36.3 ± 1.42	ND ±	105.2 ± 6.15	9.8 ± 0.54	547.6 ± 0.201	8.24 ± 0.05
			8.9 ± 0.28		12.5 ± 1.08		9.99 ± 0.602
1-Dec	fourth run		3 ± 0.07		7.8 ± 0.5		19.4 ± 3.4
		18 ± 1.05	1.5 ± 0.1	76.4 ± 2.39	7 ± 0.42	254 ± 1.66	16.1 ± 2.53
			2.4 ± 0.1		7.5 ± 0.16		11.2 ± 2.04
15-Dec	fifth run		1.5 ± 0.08		4.8 ± 0.12		13.5 ± 0.3
		35.5 ± 1.02	1.3 ± 0.07	97.7 ± 1.26	5.4 ± 0.14	450 ± 0.43	10.4 ± 0.06
			0.3 ± 0.13		5.2 ± 0.32		5.8 ± 0.1
22-Dec	sixth run		ND ±		10.2 ± 1.13		18.7 ± 1.04
		36.6 ± 3.44	ND ±	59.9 ± 3.23	5.9 ± 0.29	208 ± 2.3	16.5 ± 2.48
			4.3 ± 0.15		6.6 ± 0.34		13.3 ± 1.31
29-Dec	seventh run		ND ±		7.6 ± 0.74		36 ± 0.82
		13.5 ± 0.48	0.2 ± 0.11	59.6 ± 4.78	5.8 ± 0.08	316 ± 3.47	31.9 ± 0.31
			0.7 ± 0.11		6.6 ± 0.12		16.3 ± 0.75
13-Feb	eighth run	0	ND ±	0	4.1 ± 0.63	0	37.7 ± 0.3
			0.9 ± 0.91		5.7 ± 1.92		27 ± 0.33

Table 9: Metals data for bioretention area column 7

Column 8

Date	Run	Pb in	Pb out	Cu in	Cu out	Zn in	Zn out
20-Oct	first run	41.9 ± 3.14	ND ±	29.6 ± 0.92	18.4 ± 0.91	565.7 ± 2.324	4.18 ± 0.358
			ND ±		13.7 ± 0.86		2.39 ± 0.097
			ND ±		15.6 ± 1.04		1.31 ± 0.027
3-Nov	second run	10.6 ± 0.83	ND ±	11.1 ± 0.07	8.6 ± 0.53	147.5 ± 0.105	9.35 ± 1.242
			ND ±		8.2 ± 0.35		5.87 ± 0.197
			ND ±		8.3 ± 0.49		2.57 ± 0.41
17-Nov	third run	36.3 ± 1.42	ND ±	105.2 ± 6.15	6.7 ± 0.42	547.6 ± 0.201	11.92 ± 0.02
			ND ±		6.6 ± 0.24		4.68 ± 0.109
			3.3 ± 0.8		7.3 ± 0.72		5.14 ± 0.233
1-Dec	fourth run	18 ± 1.05	3.1 ± 0.35	76.4 ± 2.39	6.8 ± 0.26	254 ± 1.66	15.8 ± 3.01
			3 ± 0.4		6.8 ± 0.02		19.4 ± 1.53
			3.1 ± 0.35		6.5 ± 0.01		14.3 ± 1.03
15-Dec	fifth run	35.5 ± 1.02	0.8 ± 0.02	97.7 ± 1.26	6.3 ± 0.2	450 ± 0.43	14 ± 1.84
			1.1 ± 0.09		6.1 ± 0.38		9.2 ± 0.77
			0.2 ± 0.13		8.5 ± 1.04		2.3 ± 0.12
22-Dec	sixth run	36.6 ± 3.44	ND ±	59.9 ± 3.23	7.6 ± 0.47	208 ± 2.3	23.7 ± 2.01
			ND ±		6.3 ± 0.3		17.4 ± 1.24
			3.1 ± 0.04		8.3 ± 0.4		11.8 ± 0.85
29-Dec	seventh run	13.5 ± 0.48	ND ±	59.6 ± 4.78	4.9 ± 0.8	316 ± 3.47	61.6 ± 0.52
			0.3 ± 0.2		5.3 ± 0.27		28.5 ± 0.06
			1.5 ± 0.13		6.6 ± 0.22		16.6 ± 0.66
13-Feb	eighth run	0	0.8 ± 0.66	0	4.7 ± 0.1	0	26.7 ± 0.59
			0.1 ± 0.46		4 ± 0.21		20.6 ± 1.07

Table 10: Metals data for bioretention area column 8

Column 9

Date	Run	Pb in	Pb out	Cu in	Cu out	Zn in	Zn out
20-Oct	first run		ND ±		18.4 ± 0.22		5.5 ± 0.73
		41.9 ± 3.14	ND ±	29.6 ± 0.92	13.7 ± 0.48	565.7 ± 2.324	3.9 ± 0.13
			ND ±		15.6 ± 0.56		2.7 ± 0.04
3-Nov	second run		ND ±		9.1 ± 0.94		9.4 ± 0.14
		10.6 ± 0.83	ND ±	11.1 ± 0.07	8.2 ± 0.35	147.5 ± 0.105	3.5 ± 0.16
			ND ±		8.3 ± 0.49		1.8 ± 0.09
17-Nov	third run		ND ±		6.7 ± 0.42		9.6 ± 0.16
		36.3 ± 1.42	ND ±	105.2 ± 6.15	6.6 ± 0.24	547.6 ± 0.201	6.7 ± 0.06
			1.7 ± 0.52		7.3 ± 0.72		8.2 ± 0.30
1-Dec	fourth run		1.7 ± 0.1		6.8 ± 0.26		15.0 ± 1.56
		18 ± 1.05	1.8 ± 0.2	76.4 ± 2.39	6.8 ± 0.02	254 ± 1.66	23.9 ± 1.42
			1.6 ± 0.1		6.5 ± 0.01		5.4 ± 0.67
15-Dec	fifth run		0.6 ± 0.02		6.3 ± 0.2		11.9 ± 0.10
		35.5 ± 1.02	0.7 ± 0.07	97.7 ± 1.26	6.1 ± 0.38	450 ± 0.43	16.0 ± 2.05
			0.1 ± 0.07		8.5 ± 1.04		5.1 ± 0.12
22-Dec	sixth run		ND ±		7.6 ± 0.47		17.8 ± 0.74
		36.6 ± 3.44	ND ±	59.9 ± 3.23	6.3 ± 0.3	208 ± 2.3	31.3 ± 1.06
			2.5 ± 0.1		8.3 ± 0.4		19.2 ± 0.68
29-Dec	seventh run		ND ±		4.9 ± 0.8		33.8 ± 0.86
		13.5 ± 0.48	0.1 ± 0.1	59.6 ± 4.78	5.3 ± 0.27	316 ± 3.47	64.9 ± 0.28
			0.7 ± 0.07		6.6 ± 0.22		17.4 ± 0.65
13-Feb	eighth run	0	ND ±	0	4.7 ± 1.11	0	54.5 ± 0.23
			ND ±		4.9 ± 1.49		14.0 ± 0.64

Table 11: Metals data for bioretention area column 9

Column 10

Date	Run	Pb in	Pb out	Cu in	Cu out	Zn in	Zn out
20-Oct	first run		ND ±		20.8 ± 1.95		0.76 ± 0.088
		41.9 ± 3.14	ND ±	29.6 ± 0.92	21 ± 1.16	565.7 ± 2.324	6.9 ± 0.366
			ND ±		26.3 ± 0.87		1.77 ± 0.038
3-Nov	second run		ND ±		10 ± 0.26		35.36 ± 0.177
		10.6 ± 0.83	ND ±	11.1 ± 0.07	9.6 ± 1.06	147.5 ± 0.105	10.51 ± 0.529
			ND ±		11.2 ± 0.26		2.66 ± 0.352
17-Nov	third run		ND ±		10.7 ± 0.44		10.53 ± 0.022
		36.3 ± 1.42	ND ±	105.2 ± 6.15	10.4 ± 0.62	547.6 ± 0.201	20.4 ± 0.143
			1.2 ± 0.43		8.5 ± 0.79		6.2 ± 0.17
1-Dec	fourth run		0.8 ± 0.33		11 ± 0.37		18.7 ± 0.81
		18 ± 1.05	1.1 ± 0.24	76.4 ± 2.39	8.5 ± 0.05	254 ± 1.66	25.7 ± 1.09
			1.5 ± 0.15		5 ± 0.14		48.5 ± 1.25
15-Dec	fifth run		ND ±		4.6 ± 0.32		13.6 ± 0.29
		35.5 ± 1.02	0.2 ± 0.02	97.7 ± 1.26	3.6 ± 0.23	450 ± 0.43	13.1 ± 0.18
			ND ±		7.2 ± 0.14		12.9 ± 0.73
22-Dec	sixth run		ND ±		13.2 ± 1.13		27.6 ± 0.54
		36.6 ± 3.44	ND ±	59.9 ± 3.23	5.2 ± 1.08	208 ± 2.3	18.3 ± 1.08
			ND ±		4.3 ± 0.35		12.4 ± 0.76
29-Dec	seventh run		ND ±		8.7 ± 0.79		30.2 ± 0.25
		13.5 ± 0.48	ND ±	59.6 ± 4.78	2.9 ± 0.28	316 ± 3.47	33.8 ± 1.29
			ND ±		3.3 ± 0.26		27.5 ± 1.17
13-Feb	eighth run	0	ND ±	0	4 ± 1.16	0	64.9 ± 1.24
			0.8 ± 0.23		5.1 ± 1.12		20.5 ± 0.32

Table 12: Metals data for bioretention area column 10

Column 11

		Pb in			Pb out			Cu in			Cu out			Zn in			Zn out		
20-Oct	first run	41.9	±	3.14	ND	±		29.6	±	0.92	31.7	±	1.58	565.7	±	2.324	4.3	±	0.36
					ND	±					37.4	±	1.26				3.8	±	0.16
					ND	±					49.1	±	1.79				2.1	±	0.07
3-Nov	second run	10.6	±	0.83	ND	±		11.1	±	0.07	13.9	±	0.37	147.5	±	0.105	11.4	±	0.22
					ND	±					15.8	±	0.12				10.0	±	0.55
					ND	±					16.2	±	0.48				2.6	±	0.51
17-Nov	third run	36.3	±	1.42	ND	±		105.2	±	6.15	11.5	±	0.24	547.6	±	0.201	12.0	±	0.28
					ND	±					12.6	±	0.58				15.9	±	0.25
					2.8	±	0.4				16.8	±	0.68				11.8	±	0.09
1-Dec	fourth run	18	±	1.05	1.3	±	0.14	76.4	±	2.39	8.1	±	0.35	254	±	1.66	20.0	±	1.43
					1.8	±	0.19				8.6	±	0.26				34.1	±	0.28
					0.7	±	0.12				11.4	±	0.56				21.4	±	0.51
15-Dec	fifth run	35.5	±	1.02	0.1	±	0.09	97.7	±	1.26	6.8	±	0.21	450	±	0.43	17.6	±	1.01
					0.6	±	0.17				11.3	±	0.22				25.5	±	0.27
					0.1	±	0.09				7.2	±	0.98				12.5	±	0.30
22-Dec	sixth run	36.6	±	3.44	ND	±		59.9	±	3.23	11.6	±	0.74	208	±	2.3	31.8	±	0.45
					ND	±					9.3	±	0.56				19.3	±	0.76
					0.7	±	0.09				12	±	1.05				15.6	±	1.03
29-Dec	seventh run	13.5	±	0.48	ND	±		59.6	±	4.78	8.3	±	0.67	316	±	3.47	43.8	±	0.90
					ND	±					8	±	0.19				43.0	±	0.95
					0.3	±	0.11				10.7	±	0.82				15.3	±	1.16
13-Feb	eighth run		0		0.5	±	0.1		0		8.8	±	1.97		0		109.0	±	0.50
					0.6	±	0.34				9.6	±	2.59				32.1	±	0.21

Table 13: Metals data for bioretention area column 11

Column 12

Date	Run	Pb in	Pb out	Cu in	Cu out	Zn in	Zn out
20-Oct	first run		ND ±		27.2 ± 1.36		7.6 ± 0.89
		41.9 ± 3.14	ND ±	29.6 ± 0.92	101 ± 2.73	565.7 ± 2.324	4.7 ± 0.03
			ND ±		39.6 ± 1.58		2.8 ± 0.04
3-Nov	second run		ND ±		11.4 ± 0.91		12.7 ± 0.28
		10.6 ± 0.83	ND ±	11.1 ± 0.07	14.1 ± 0.47	147.5 ± 0.105	8.0 ± 0.13
			ND ±		16.6 ± 0.74		5.1 ± 0.23
17-Nov	third run		ND ±		8.1 ± 0.18		14.9 ± 0.07
		36.3 ± 1.42	ND ±	105.2 ± 6.15	12.6 ± 0.24	547.6 ± 0.201	11.8 ± 0.04
			2.8 ± 0.4		13.9 ± 0.24		10.9 ± 0.95
1-Dec	fourth run		2.5 ± 0.3		7.6 ± 0.54		22.5 ± 6.31
		18 ± 1.05	2.3 ± 0.5	76.4 ± 2.39	6.9 ± 0.12	254 ± 1.66	23.2 ± 0.14
			1.4 ± 0.1		8.2 ± 0.21		15.6 ± 3.13
15-Dec	fifth run		0.3 ± 0.05		5.5 ± 0.37		15.0 ± 0.96
		35.5 ± 1.02	0.7 ± 0.12	97.7 ± 1.26	7 ± 0.32	450 ± 0.43	18.7 ± 0.13
			ND ±		6.9 ± 0.56		7.3 ± 0.54
22-Dec	sixth run		ND ±		10.8 ± 0.83		26.4 ± 0.81
		36.6 ± 3.44	ND ±	59.9 ± 3.23	8.1 ± 0.2	208 ± 2.3	31.9 ± 0.57
			0.5 ± 0.12		9 ± 1.1		17.8 ± 0.67
29-Dec	seventh run		ND ±		9.5 ± 0.44		37.3 ± 0.83
		13.5 ± 0.48	ND ±	59.6 ± 4.78	6.5 ± 0.63	316 ± 3.47	36.6 ± 0.54
			0.6 ± 0.11		9.6 ± 0.41		32.3 ± 0.49
13-Feb	eighth run	0	ND ±	0	4.8 ± 1.45	0	62.8 ± 1.03
			0.5 ± 0.12		4.7 ± 0.55		22.4 ± 0.37

Table 14: Metals data for bioretention area column 12

Column 13

Date	Run	Pb in			Pb out			Cu in			Cu out			Zn in			Zn out		
20-Oct	first run				ND	±					30.8	±	1.36				3.8	±	0.42
		34.5	±	2.24	ND	±		36.6	±	0.79	20.6	±	1.78	609.2	±	1.729	10.1	±	0.66
					ND	±					27.8	±	1.94				6.9	±	0.45
3-Nov	second run				3.7	±					13	±	0.49				38.5	±	0.40
		6.3	±	0.82	ND	±		22.1	±	1.55	13.5	±	0.87	109.9	±	2.45	26.2	±	0.38
					ND	±					15	±	0.61				12.9	±	0.31
17-Nov	third run				ND	±					12.6	±	0.53				20.1	±	0.34
		24.9	±	1.64	ND	±		77.5	±	12.84	9.1	±	0.55	478.8	±	1.11	15.1	±	0.35
					2.4	±	0.77				12.1	±	0.66				13.7	±	0.29
1-Dec	fourth run				3.4	±	0.31				8.5	±	0.31				37.8	±	3.36
		8.2	±	0.95	2.1	±	0.22	66.1	±	3.04	5.9	±	0.2	476	±	6.36	37.6	±	0.42
					2.4	±	0.11				5.7	±	0.14				37.5	±	2.48
15-Dec	fifth run				ND	±					4.6	±	0.1				24.0	±	0.17
		15.7	±	0.33	ND	±		48.6	±	0.83	3.9	±	0.16	140	±	0.07	20.7	±	0.24
					ND	±					11.3	±	0.11				21.9	±	0.14
22-Dec	sixth run				ND	±					8.1	±	0.92				42.6	±	2.11
		5.2	±	0.7	ND	±		11.7	±	1.74	5.1	±	0.38	284	±	7.83	36.8	±	1.06
					ND	±					4.5	±	0.36				29.3	±	1.23
29-Dec	seventh run				ND	±					4.9	±	0.68				48.6	±	0.73
		23.6	±	0.97	ND	±		62.2	±	6.17	3.3	±	0.22	260	±	2.97	53.5	±	0.06
					ND	±					4.5	±	0.19				50.6	±	1.05
13-Feb	eighth run				ND	±					4.8	±	1.87				93.0	±	0.75
		0						0						0					
					0.2	±	0.79				4.8	±	0.46				91.0	±	0.96

Table 15: Metals data for bioretention area column 13

Column 14

Date	Run	Pb in	Pb out	Cu in	Cu out	Zn in	Zn out
20-Oct	first run		ND ±		45.1 ± 1.55		2.8 ± 0.98
		34.5 ± 2.24	ND ±	36.6 ± 0.79	45.9 ± 1.37	609.2 ± 1.729	5.0 ± 0.96
			ND ±		45.3 ± 1.63		8.2 ± 0.36
3-Nov	second run		ND ±		20 ± 0.2		11.4 ± 3.25
		6.3 ± 0.82	ND ±	22.1 ± 1.55	21.5 ± 2.86	109.9 ± 2.45	10.4 ± 3.11
			ND ±		26.6 ± 1.36		18.4 ± 0.14
17-Nov	third run		ND ±		19 ± 0.97		15.7 ± 0.65
		24.9 ± 1.64	ND ±	77.5 ± 12.84	19.8 ± 1.39	478.8 ± 1.11	13.6 ± 0.32
			ND ±		25.8 ± 4.74		20.4 ± 0.17
1-Dec	fourth run		3.1 ± 0.29		14.4 ± 0.33		68.9 ± 1.34
		8.2 ± 0.95	2.5 ± 0.26	66.1 ± 3.04	15.3 ± 0.35	476 ± 6.36	30.1 ± 1.48
			3.8 ± 0.51		15.1 ± 0.74		9.8 ± 0.12
15-Dec	fifth run		ND ±		4.2 ± 0.19		31.0 ± 2.91
		15.7 ± 0.33	ND ±	48.6 ± 0.83	11.6 ± 0.28	140 ± 0.07	12.4 ± 0.32
			ND ±		13.9 ± 1.11		13.6 ± 0.06
22-Dec	sixth run		ND ±		15 ± 1.87		45.7 ± 0.99
		5.2 ± 0.7	ND ±	11.7 ± 1.74	16.8 ± 0.31	284 ± 7.83	36.5 ± 0.58
			ND ±		16.1 ± 0.17		22.1 ± 1.07
29-Dec	seventh run		ND ±		12.5 ± 0.06		38.5 ± 0.17
		23.6 ± 0.97	ND ±	62.2 ± 6.17	12.4 ± 0.21	260 ± 2.97	34.0 ± 0.20
			ND ±		11.9 ± 0.2		60.7 ± 0.17

Table 16: Metals data for bioretention area column 14

Column 15

		Pb						Cu						Zn					
		in			out			in			out			in			out		
20-Oct	first run	34.5	±	2.24	ND	±		36.6	±	0.79	30.6	±	0.64	609.2	±	1.729	2.9	±	0.75
					ND	±					28.3	±	0.73				6.2	±	2.66
					ND	±					27	±	0.84				8.2	±	0.81
3-Nov	second run	6.3	±	0.82	ND	±		22.1	±	1.55	16.3	±	0.32	109.9	±	2.45	20.4	±	0.59
					ND	±					14.3	±	0.35				11.9	±	0.22
					ND	±					14.2	±	0.81				23.3	±	1.16
17-Nov	third run	24.9	±	1.64	ND	±		77.5	±	12.84	11.7	±	0.32	478.8	±	1.11	13.7	±	0.47
					ND	±					11.6	±	0.6				14.4	±	0.45
					0.6	±	0.1				13.8	±	0.5				24.8	±	0.07
1-Dec	fourth run	8.2	±	0.95	1.8	±	0.48	66.1	±	3.04	11.9	±	0.23	476	±	6.36	27.3	±	0.49
					2.3	±	0.92				10.1	±	0.15				34.3	±	1.15
					2.9	±	0.87				9.1	±	0.08				31.8	±	1.48
15-Dec	fifth run	36.6	±	1.94	ND	±		48.6	±	0.83	12.4	±	0.3	140	±	0.07	18.4	±	0.21
					ND	±					9.1	±	0.43				17.3	±	0.23
					ND	±					7.7	±	0.39				17.6	±	0.14
22-Dec	sixth run	5.2	±	0.7	ND	±		11.7	±	1.74	12	±	0.4	284	±	7.83	27.7	±	0.78
					ND	±					14.7	±	1.2				31.3	±	0.52
					ND	±					11.2	±	0.56				33.8	±	0.89
29-Dec	seventh run	23.6	±	0.97	ND	±		62.2	±	6.17	8.6	±	0.23	260	±	2.97	66.9	±	0.22
					ND	±					9.7	±	1.36				72.7	±	0.08
					ND	±					9	±	0.18				72.2	±	0.56
13-Feb	eighth run	0			ND	±		0			5.9	±	1.43	0			74.1	±	1.19
					ND	±					5.9	±	1.05				129.0	±	0.80

Table 17: Metals data for bioretention area column 15

Column 1

Date	Run	NO3 in			NO3 out			PO4 in			PO4 out		
20-Oct	first run	0.67	±	0.0012	13.533	±	0.1527	0.15	±	0.01	0.368	±	0.0028
											MDL		0.012
3-Nov	second run	0.39	±	0.008	1.94	±	0.006	0.087	±	0.0006	0.827	±	0.0017
					MDL		0.009						
17-Nov	third run	2.02	±	0.01	9	±	0.025	0.462	±	0.001	1.5	±	0.0058
					MDL		0.009				MDL		0.01
1-Dec	fourth run	2.08	±	0.015	6.19	±	0.275	1.12	±	0	1.92	±	0
15-Dec	fifth run	1.72	±	0.012	4.31	±	0.02	0.619	±	0.014	2.42	±	0.006
					MDL		0.007				MDL		0.012
22-Dec	sixth run	1.68	±	0.015	6.09	±	0.057	0.506	±	0.0057	1.51	±	0.0057
					MDL		0.007						
29-Dec	seventh run	2.24	±	0.083	4.44	±	0.075	0.515	±	0.002	1.48	±	0.0057
					MDL		0.008				MDL		0.006
13-Feb	eighth run		0		13.1	±	0.058		0		1.14	±	0.0057
					MDL		0.009				MDL		0.009

Table 18: Nutrient data for bioretention area column 1

Column 2

		NO3						PO4					
		in			out			in			out		
20-Oct	first run	0.67	±	0.0012	7.4133	±	0.0513	0.15	±	0.01	0.441	±	0.0012
3-Nov	second run	0.39	±	0.008	2.48	±	0.012	0.087	±	0.0006	0.335	±	0.0038
17-Nov	third run	2.02	±	0.01	10.3	±	0.058	0.462	±	0.001	0.603	±	0.0015
1-Dec	fourth run	2.08	±	0.015	13	±	0.153	1.12	±	0	0.521	±	0.0021
15-Dec	fifth run	1.72	±	0.012	8.56	±	0.04	0.619	±	0.014	0.467	±	0.0015
22-Dec	sixth run	1.68	±	0.015	6.42	±	0.11	0.506	±	0.0057	0.415	±	0.002
29-Dec	seventh run	2.24	±	0.083	6.29	±	0.015	0.515	±	0.002	0.539	±	0.0133
13-Feb	eighth run		0		23	±	0.208		0		0.378	±	0.01

Table 19: Nutrient data for bioretention area column 2

Column 3

		NO3						PO4					
		in			out			in			out		
20-Oct	first run	0.67	±	0.0012	12.47	±	0.1155	0.15	±	0.01	0.46	±	0.0075
3-Nov	second run	0.39	±	0.008	1.26	±	0.006	0.087	±	0.0006	0.907	±	0.001
17-Nov	third run	2.02	±	0.01	7.58	±	0.025	0.462	±	0.001	1.45	±	0.0012
1-Dec	fourth run	2.08	±	0.015	7.58	±	0.057	1.12	±	0	1.67	±	0.0058
15-Dec	fifth run	1.72	±	0.012	7.81	±	0.044	0.619	±	0.014	1.8	±	0.0057
22-Dec	sixth run	1.68	±	0.015	5.46	±	0.06	0.506	±	0.0057	1.13	±	0
29-Dec	seventh run	2.24	±	0.083	5.66	±	0.01	0.515	±	0.002	1.39	±	0
13-Feb	eighth run		0		13.3	±	0		0		1.04	±	0.0057

Table 20: Nutrient data for bioretention area column 3

Column 4

		NO3						PO4					
		in			out			in			out		
20-Oct	first run	0.67	±	0.0012	8.81	±	0.0379	0.15	±	0.01	0.342	±	0.0046
3-Nov	second run	0.39	±	0.008	2.57	±	0.006	0.087	±	0.0006	0.802	±	0.0006
17-Nov	third run	2.02	±	0.01	8.56	±	0.023	0.462	±	0.001	1.65	±	0
1-Dec	fourth run	2.08	±	0.015	6.39	±	0.062	1.12	±	0	1.95	±	0.0057
15-Dec	fifth run	1.72	±	0.012	1.89	±	0.023	0.619	±	0.014	2.07	±	0.0153
22-Dec	sixth run	1.68	±	0.015	4.76	±	0.015	0.506	±	0.0057	1.18	±	0
29-Dec	seventh run	2.24	±	0.083	7.29	±	0.059	0.515	±	0.002	1.46	±	0
13-Feb	eighth run		0		9.96	±	0.046		0		1.23	±	0.0057

Table 21: Nutrient data for bioretention area column 4

Column 5

		NO3						PO4					
		in			out			in			out		
20-Oct	first run	0.67	±	0.0012	9.04	±	0.0153	0.15	±	0.01	0.303	±	0.0228
3-Nov	second run	0.39	±	0.008	2.23	±	0	0.087	±	0.0006	1	±	0
17-Nov	third run	2.02	±	0.01	7.57	±	0.012	0.462	±	0.001	1.67	±	0
1-Dec	fourth run	2.08	±	0.015	13.1	±	0.058	1.12	±	0	2.44	±	0
15-Dec	fifth run	1.72	±	0.012	3.73	±	0.006	0.619	±	0.014	2.45	±	0.0057
22-Dec	sixth run	1.68	±	0.015	6.98	±	0.055	0.506	±	0.0057	1.2	±	0.0057
29-Dec	seventh run	2.24	±	0.083	4.87	±	0.012	0.515	±	0.002	1.83	±	0
13-Feb	eighth run		0		21	±	0.115		0		0.705	±	0.012

Table 22: Nutrient data for bioretention area column 5

Column 6

Date	Run	NO3 in			NO3 out			PO4 in			PO4 out		
20-Oct	first run	0.67	±	0.0012	11.33	±	0.0577	0.15	±	0.01	0.268	±	0.0006
3-Nov	second run	0.39	±	0.008	2.3	±	0.006	0.087	±	0.0006	0.614	±	0.0026
17-Nov	third run	2.02	±	0.01	4.94	±	0.015	0.462	±	0.001	1.53	±	0
1-Dec	fourth run	2.08	±	0.015	9.32	±	0.06	1.12	±	0	2.2	±	0.0057
15-Dec	fifth run	1.72	±	0.012	7.92	±	0.035	0.619	±	0.014	2.22	±	0
22-Dec	sixth run	1.68	±	0.015	5.18	±	0	0.506	±	0.0057	1.47	±	0.021
29-Dec	seventh run	2.24	±	0.083	7.68	±	0.012	0.515	±	0.002	1.78	±	0
13-Feb	eighth run		0		21.6	±	0.115		0		1.2	±	0.026

Table 23: Nutrient data for bioretention area column 6

Column 7

		NO3						PO4					
		in			out			in			out		
20-Oct	first run	0.38	±	0.0207	0.84	±	0.0006	0.07	±	0.005	0.511	±	0.0052
3-Nov	second run	0.369	±	0.0006	0.625	±	0.002	0.085	±	0.0004	1.07	±	0
17-Nov	third run	2.36	±	0.006	3.81	±	0.006	0.564	±	0.0021	1.75	±	0.0058
1-Dec	fourth run	2.03	±	0.01	5.8	±	0.042	0.482	±	0.0014	1.61	±	0
15-Dec	fifth run	2.34	±	0.022	0.944	±	0.022	0.739	±	0.0026	2.19	±	0.0057
22-Dec	sixth run	1.71	±	0.021	0.703	±	0.276	0.516	±	0.0035	2.32	±	0.0057
29-Dec	seventh run	1.9	±	0.029	1.77	±	0.104	0.456	±	0.0015	1.87	±	0
13-Feb	eighth run		0		11.3	±	0.1		0		0.635	±	0.004

Table 24: Nutrient data for bioretention area column 7

Column 8

		NO3						PO4					
		in			out			in			out		
20-Oct	first run	0.38	±	0.0207	2.23	±	0.0404	0.07	±	0.005	0.273	±	0.0032
3-Nov	second run	0.369	±	0.0006	1.45	±	0.006	0.085	±	0.0004	1.31	±	0
17-Nov	third run	2.36	±	0.006	4.13	±	0.006	0.564	±	0.0021	2.36	±	0.0058
1-Dec	fourth run	2.03	±	0.01	5.43	±	0.067	0.482	±	0.0014	2.57	±	0.0057
15-Dec	fifth run	2.34	±	0.022	5.65	±	0	0.739	±	0.0026	2.26	±	0
22-Dec	sixth run	1.71	±	0.021	1.15	±	0.01	0.516	±	0.0035	2.47	±	0.0115
29-Dec	seventh run	1.9	±	0.029	8.24	±	0.015	0.456	±	0.0015	1.48	±	0.0057
13-Feb	eighth run		0		7.48	±	0.042		0		0.689	±	0.031

Table 25: Nutrient data for bioretention area column 8

Column 9

		NO3						PO4					
		in			out			in			out		
20-Oct	first run	0.38	±	0.0207	1.86	±	0.0231	0.07	±	0.005	0.398	±	0.017
3-Nov	second run	0.369	±	0.0006	0.57	±	0	0.085	±	0.0004	0.362	±	0.001
17-Nov	third run	2.36	±	0.006	2.68	±	0.006	0.564	±	0.0021	0.871	±	0.0137
1-Dec	fourth run	2.03	±	0.01	9.67	±	0.049	0.482	±	0.0014	0.704	±	0.002
15-Dec	fifth run	2.34	±	0.022	1.65	±	0.012	0.739	±	0.0026	1.47	±	0
22-Dec	sixth run	1.71	±	0.021	0.87	±	0.001	0.516	±	0.0035	1.01	±	0
29-Dec	seventh run	1.9	±	0.029	1.07	±	0.006	0.456	±	0.0015	0.914	±	0.0023
13-Feb	eighth run		0		22.8	±	0.058		0		0.81	±	0.017

Table 26: Nutrient data for bioretention area column 9

Column 10

		NO3						PO4					
		in			out			in			out		
20-Oct	first run	0.38	±	0.0207	1.07	±	0.0058	0.07	±	0.005	0.733	±	0.0078
3-Nov	second run	0.369	±	0.0006	1.41	±	0.006	0.085	±	0.0004	1.16	±	0
17-Nov	third run	2.36	±	0.006	1.09	±	0.006	0.564	±	0.0021	1.43	±	0
1-Dec	fourth run	2.03	±	0.01	9.59	±	0.09	0.482	±	0.0014	1.26	±	0.0057
15-Dec	fifth run	2.34	±	0.022	0.876	±	0.008	0.739	±	0.0026	1.65	±	0
22-Dec	sixth run	1.71	±	0.021	0.78	±	0.0006	0.516	±	0.0035	1.27	±	0
29-Dec	seventh run	1.9	±	0.029	0.857	±	0.002	0.456	±	0.0015	1.2	±	0
13-Feb	eighth run		0		39.4	±	0.503		0		0.129	±	0.014

Table 27: Nutrient data for bioretention area column 10

Column 11

		NO3						PO4					
		in			out			in			out		
20-Oct	first run	0.38	±	0.0207	1.78	±	0.0231	0.07	±	0.005	0.96	±	0.0035
3-Nov	second run	0.369	±	0.0006	1.22	±	0	0.085	±	0.0004	0.393	±	0.0096
17-Nov	third run	2.36	±	0.006	5.25	±	0.01	0.564	±	0.0021	0.562	±	0
1-Dec	fourth run	2.03	±	0.01	21.8	±	0.153	0.482	±	0.0014	0.425	±	0.0032
15-Dec	fifth run	2.34	±	0.022	3.49	±	0.035	0.739	±	0.0026	0.588	±	0.013
22-Dec	sixth run	1.71	±	0.021	1.56	±	0.025	0.516	±	0.0035	0.419	±	0.0318
29-Dec	seventh run	1.9	±	0.029	1.64	±	0	0.456	±	0.0015	0.452	±	0.001
13-Feb	eighth run		0		47.2	±	1.8		0		0.317	±	0.012

Table 28: Nutrient data for bioretention area column 11

Column 12

		NO3						PO4					
		in			out			in			out		
20-Oct	first run	0.38	±	0.0207	1.41	±	0	0.07	±	0.005	0.348	±	0.0156
3-Nov	second run	0.369	±	0.0006	0.59	±	0.002	0.085	±	0.0004	0.478	±	0.0021
17-Nov	third run	2.36	±	0.006	4.4	±	0.012	0.564	±	0.0021	1.48	±	0
1-Dec	fourth run	2.03	±	0.01	14.3	±	0.321	0.482	±	0.0014	0.875	±	0.0006
15-Dec	fifth run	2.34	±	0.022	0.596	±	0.012	0.739	±	0.0026	2.47	±	0
22-Dec	sixth run	1.71	±	0.021	0.545	±	0.01	0.516	±	0.0035	2.42	±	0
29-Dec	seventh run	1.9	±	0.029	0.597	±	0.004	0.456	±	0.0015	2.29	±	0
13-Feb	eighth run		0		47	±	2.3		0		0.292	±	0.003

Table 29: Nutrient data for bioretention area column 12

Column 13

		NO3						PO4					
		in			out			in			out		
20-Oct	first run	0.54	±	0.0077	0.88	±	0.0031	0.1	±	0.027	0.593	±	0.0031
3-Nov	second run	0.415	±	0.001	0.72	±	0.002	0.089	±	0.0003	0.716	±	0.0012
17-Nov	third run	1.74	±	0.006	1.02	±	0.006	0.486	±	0.0017	1.05	±	0.0058
1-Dec	fourth run	1.96	±	0.017	0.607	±	0.008	0.524	±	0.001	1.41	±	0
15-Dec	fifth run	1.68	±	0.023	0.845	±	0.004	0.668	±	0.0015	1.75	±	0
22-Dec	sixth run	1.12	±	0.006	0.307	±	0.008	0.897	±	0.0015	1.39	±	0.0057
29-Dec	seventh run	2.14	±	0.035	0.34	±	0.017	0.625	±	0.0006	1.71	±	0.0057
13-Feb	eighth run		0		6.18	±	0.021		0		0.45	±	0.009

Table 30: Nutrient data for bioretention area column 13

Column 14

		NO3						PO4					
		in			out			in			out		
20-Oct	first run	0.54	±	0.0077	2.53	±	0.0153	0.1	±	0.027	0.312	±	0.002
3-Nov	second run	0.415	±	0.001	3.52	±	0.055	0.089	±	0.0003	0.229	±	0.0006
17-Nov	third run	1.74	±	0.006	2.21	±	0.01	0.486	±	0.0017	0.268	±	0.001
1-Dec	fourth run	1.96	±	0.017	1.59	±	0.01	0.524	±	0.001	0.332	±	0
15-Dec	fifth run	1.68	±	0.023	1.3	±	0.006	0.668	±	0.0015	0.299	±	0.0156
22-Dec	sixth run	1.12	±	0.006	1.96	±	0	0.897	±	0.0015	0.214	±	0.0006
29-Dec	seventh run	2.14	±	0.035	0.98	±	0.006	0.625	±	0.0006	0.259	±	0.0006

Table 31: nutrient data for bioretention area column 14

Column 15

		NO3						PO4					
		in			out			in			out		
20-Oct	first run	0.54	±	0.0077	1.07	±	0.0208	0.1	±	0.027	0.446	±	0.0055
3-Nov	second run	0.415	±	0.001	2.49	±	0.006	0.089	±	0.0003	0.517	±	0.001
17-Nov	third run	1.74	±	0.006	2.47	±	0.015	0.486	±	0.0017	0.484	±	0.0017
1-Dec	fourth run	1.96	±	0.017	1.41	±	0.006	0.524	±	0.001	0.663	±	0.002
15-Dec	fifth run	1.68	±	0.023	0.882	±	0.004	0.668	±	0.0015	0.627	±	0.002
22-Dec	sixth run	1.12	±	0.006	0.523	±	0.003	0.897	±	0.0015	1.16	±	0
29-Dec	seventh run	2.14	±	0.035	0.57	±	0.006	0.625	±	0.0006	0.581	±	0.001
13-Feb	eighth run		0		1.35	±	0.058		0		0.762	±	0.019

Table 32: Nutrient data for bioretention area column 15

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